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unusually vigorous Yosemite Glacier. Glacial over-deepening exceeded 2,000 feet in the Yosemite region, and produced the remarkable hanging valleys for which the region is famous. Glacial over-steepening produced the steep valley walls, and made possible the effective weathering along joint planes, to which the details of cliff sculpture are due. Many of the notches in the lips of the hanging valleys are due to the joint-controlled weathering; but some are stream carved notches, deserted by their streams because of glacial interference. Both types of notches are expectable features in the side of a glacial trough located in jointed rocks.

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THE ERUPTION OF TAAL VOLCANO

The following account of the eruption of Taal Volcano on January 30, 1911 is abridged from a paper prepared by Mr. Walter E. Pratt.*

Taal Volcano, in southwestern Luzon, "began throwing out steam and mud on January 27, and continued in eruption with increasing violence during January 28 and 29, culminating in an explosive outburst early on the morning of January 30, which laid waste the surrounding country over an area of 230 kilometers, killing practically all life within this area. Mud or ashes spread over more than 2,000 square kilometers in southwestern Luzon. The activity diminished gradually to a state of normal quiescence by February 6 to 8."

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* *The Philippine Journal of Science*, Vol. VI, 1911, No. 2, pp. 63-83. 3 figs. in text and 14 plates of photo-engravings and maps.

Mr. Pratt's paper "embodies personal notes made during the two weeks immediately succeeding the eruption. In this time every part of the devastated region was visited. Information as to what happened on the night of the eruption was secured by conversations with people who had witnessed it at close range from different points of view. On January 30, the writer went to Bañadero, a town near the volcano, and during a large part of the subsequent field work Mr. Charles Martin, photographer of the Bureau of Science, was with him. Mr. Martin also was on Volcano Island just before the main eruption. . .

"Taal Volcano near the center of Lake Bombon may be said to constitute an island with the active crater centrally located on it. Its rim is low, varying from 100 to 320 meters in elevation. Its floor stood just above sea level prior to this last eruption. The volcano is about 60 kilometers south of Manila. The crater has an area of about 3 square kilometers, the island contains about 25 square kilometers, and Lake Bombon covers an area of approximately 320 square kilometers. Each is roughly oval in general outline. There were seven small *barrios* (villages) on the island and Lake Bombon was fringed with the homes of native fishermen and sugar-cane planters. . .

"There is no evidence that lava ever flowed from Taal Volcano. The crater walls, the island, and the whole surrounding country are composed of bedded volcanic tuff and agglomerates. Volcano Island contains a number of small extinct craters or cinder cones and it is generally conceded that volcanic activity formerly covered the whole area of the present lake, either as a single great crater or more probably, perhaps, as a large number of smaller craters. For a concise discussion of Taal Volcano, its geology and historic eruptions, the reader is referred to the work of Dr. George I. Adams.*

"The first intimation of the approach of the eruption was obtained from the increased size of the cloud of stream which always hangs over the active crater, and also from mild earthquakes. People as far away as Batangas (about 30 kilometers distant) began to be alarmed by these conditions on Friday, January 27. The earthquakes increased rapidly in violence and number and, on the following day, the immense white cloud, plainly visible from Batangas, was frequently blackened by the ejection of mud. The cloud rose in explosive outbursts, which were often immediately preceded by a perceptible earthquake shock. A noticeable amount of mud had already fallen on the slopes of the volcano when Mr. Martin reached the island on Sunday morning, January 29. At about 3.30 Sunday afternoon large cracks opened in the earth near the towns of Lemery and Taal. Probably also the small fissure at Talisay appeared at this time. There were fewer earthquakes recorded on Sunday than on the previous day, although severe shocks accompanied the appearance of the earth fissures. Apparently, the activity of the volcano was slightly lessened on Sunday afternoon. On Sunday evening the activity began to increase again about dark with violent outbursts from the volcano and sharp earthquakes. About 11 P.M. a very severe earthquake was followed closely by the ejection of a massive

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* Geological Reconnaissance of Southwestern Luzon. *Philipp. Journ. of Sci.* Sec. A (1910) 5, 57.

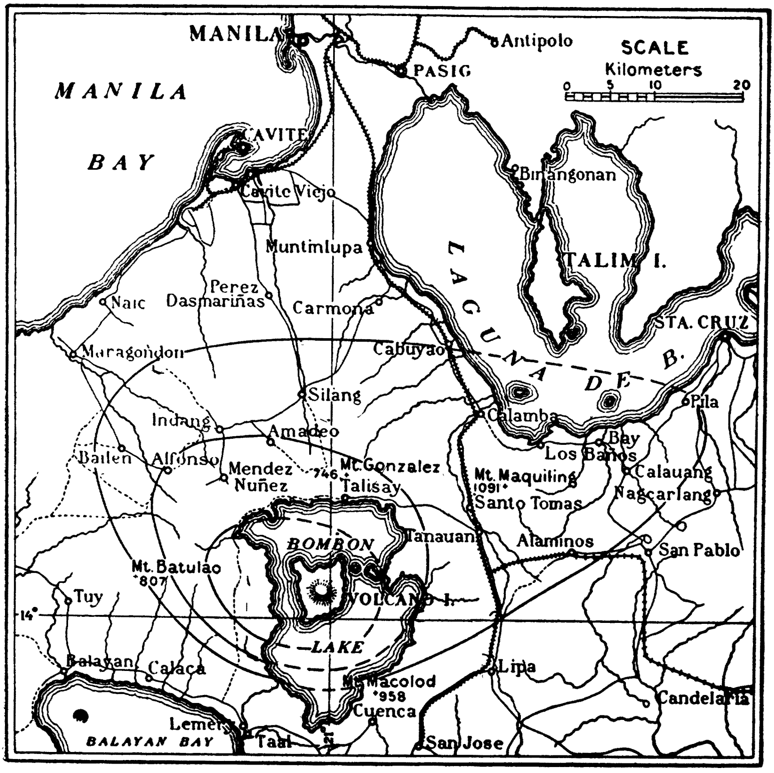

FIG. 1—Map of a part of Southwestern Luzon showing area covered by mud from the eruption.

black cloud from the volcano. From this time on, it appears, the cloud above the volcano was very frequently crossed and streaked with lightning, and often showed flashes or sheets of light. Some people saw incandescent bodies rising out of the crater and falling in graceful curves to the earth. At 1 o'clock in the morning, another outburst occurred, probably more violent than the one at 11 o'clock, but similar to it. At 2.20 o'clock in the morning, without any severe earthquake, but accompanied by a loud noise, resembling an explosion, the culminating outburst of the eruption took place. The great black cloud shot up higher than before and finally spread out at the top like an umbrella, or a giant cauliflower. The lightning became much more intense, there was much explosive noise and at some places, such as Talisay and San Nicolas, a strong wind came from the volcano. At Bañadero there was little wind, but mud began to fall. Very soon the lake suddenly rose about 2.5 meters. The mud at Bañadero was cool and fell like rain. The activity decreased gradually, and by daylight the cloud from the volcano was again white.

"This main eruption awakened many people in Manila, and in Dagupan, 240 kilometers north of the volcano, people say they were awakened at about this time by hearing a noise. The effect in Manila was that of a tremendous vibration, accompanied by the rattling of windows and loose doors. The noise seemed to pass over the city in a great wave, so that it was heard farther away, after it had ceased close at hand. No earthquake was recorded in Manila at this time."

"The eruption cloud, which rose over the volcano, emerged from the crater with explosive violence, rose rapidly to a great height and finally spread out at the top in a horizontal layer. It is doubtful if its burden of solid ejecta reached a greater height than 3,500 meters. A feature of the movement of this explosive cloud was its terrific sweep downward and outward from the crater rim. The evidence of this movement is obtained from its effect on the vegetation on the lower slopes of the volcano and the west shore of Lake Bombon. The heavy growth of cogon grass was flattened absolutely and patches of forest except where protected by the topography were completely destroyed though not burned. Broken ends of tree stumps and branches were literally shredded as though exposed to the action of a powerful sand blast. Outside the central area over which this explosive expansion of the gases was felt the eruption caused only a rain of mud which fell gently.

"This downward and outward movement is difficult of conception to those who saw the steadily rising cloud above the volcano during the activity. However, when it is recalled that explosions tend to act equally in all directions, downward as well as upward, and when it is remembered that the air above the crater was already heavy with condensing steam and falling mud when the main explosion occurred, it is apparent that expansion would naturally take place in the manner described. . . It is probable that at a greater distance from the crater than was attained by this outward expansion, the atmosphere moved toward the volcano, as a center of low pressure resulting from the upward rush of the cloud: Such a movement is evidenced by the sudden falling of barometers around the volcano. In Manila, an otherwise regular barograph at the Weather Bureau Observatory shows a sharp drop of 1 millimeter at the moment of the eruption. At Batangas a similar drop amounted to 2 millimeters. At both these places there was a slight wind toward the volcano after the eruption. . .

"For an hour or more during the greatest activity the cloud above the volcano was vivid with lightning which played in streaks, often branched or forked, and ran either up or down or obliquely over the cloud. . . Spectacular electric displays have been prominent features of many volcanic eruptions. Special descriptive names have been applied to this particular type of lightning.* Its origin has been ascribed to the generation of electricity by the intense friction occurring between the individual ash particles in the moving cloud.† Probably friction between ash particles and the air or friction of the vapor-laden gases of the rising cloud with the surrounding drier atmosphere, are contributing causes.

"The earthquakes ‡ accompanying this activity of Taal are tabulated in chronological order in a report "The Eruption of Taal Volcano, January 30, 1911" written by Father Miguel Saderra Masó, Assistant Director of the Weather Bureau. Father Masó concludes that the earth-movements were very local, that they emanated from the immediate vicinity of the volcano and that they lost intensity very rapidly as they traveled away from that center. The most violent earthquakes recorded in Manila were of intensity IV of the earthquake scale of De Rossi Forel § and Father Masó thinks it probable that even in the vicinity of the volcano no shock occurred more intense than VII. || Consequently, a shock of intensity III at

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* Hovey, E. O., Martinique and St. Vincent, *Bull. Am. Mus. Nat. Hist.* (1902), 16, 333.

† Scrope, G. P., Volcanoes, London, 2 ed. (1862), 57.

‡ The earthquakes in connection with the eruption of Taal will be the subject of a special bulletin of the Philippine Islands Weather Bureau.

§ Strong enough to shake movable objects, chairs, and windows, etc.

|| Strong enough to overturn movable objects, shake off plastering, etc.

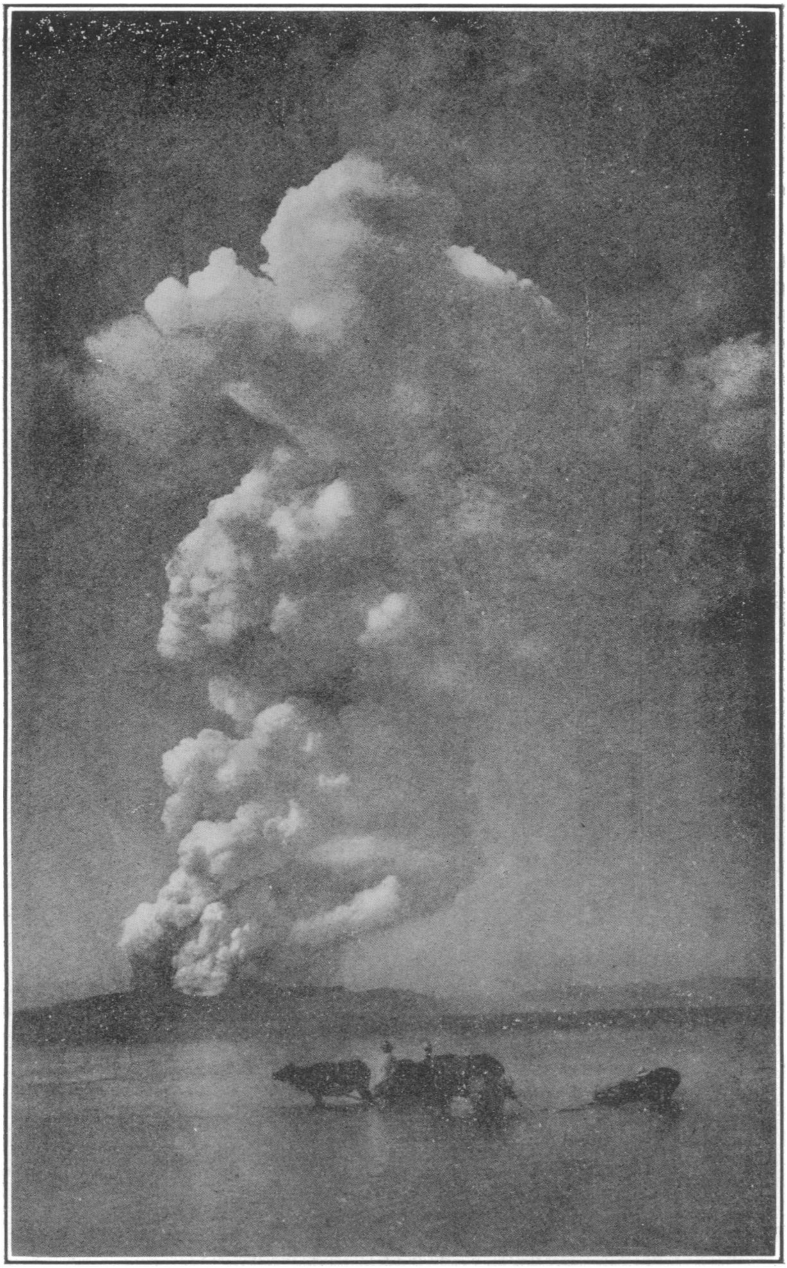

FIG. 2—Eruption cloud as it appeared from Bañadero, January 30, 1911.

the volcano might not be felt in Manila at all. It is beyond question that a great many more shocks really did occur near the volcano than were recorded in Manila. The local extent of the earthquake shocks suggests that the center of Taal's activity was not at a great depth. . .

"Damage due directly to earthquakes was slight. The towns of Taal and Lemery were most shaken. In Lemery the tower of the Casaysay Church was partly demolished. Masonry gateposts in the wall which surrounds the church were overturned and fell to the west. This church is directly in the line of one of the fissures and some of the damage is evidently due to the vertical displacement along it as the west side dropped. . . Numerous small landslides occurred in the steeply eroded hills of volcanic tuff to the west of Lake Bombon. The shocks cracked and displaced several old masonry walls in Talisay.

"Lake Bombon rose suddenly just after the main eruption. This wave (or series of waves close together) washed up on the lake shore through a vertical distance of 2.5 or 3 meters carrying away houses and causing loss of life in some of the *barrios*. If, as seems established, no severe earthquake occurred for some time before this wave was observed, its cause must be sought in another direction. The whole of Volcano Island sank from 1 to 3 meters. . . It is probable, on the whole, that the island sank gradually, causing only minor earthquakes and very slight disturbance to the lake surface. The explosive rush of gases down the volcano slopes affords a possible explanation of the water wave. This blast, the strength of which is intimated by the absolute destruction it wrought, moved with a considerable downward component (tending to expand equally in all directions) until the moment it reached the lake level. Responding to this downward pressure, the lake surface would be depressed, and its reaction would cause a wave or waves. Thus, the water would have literally been blown away from the volcano to the lake shores.*

"The known ejecta from Taal in this eruption were (1) steam (probably water also), (2) sulphur dioxide, (3) angular pieces of homogeneous extrusive rock, (4) fragmental blocks of volcanic tuffs and agglomerates, and (5) volcanic mud or ash. Steam made up practically the whole volume of the gases. The odor of sulphur dioxide was strong during the eruption and probably this gas or its oxidation product was effective in killing vegetation.* Other gases, notably carbon dioxide, may have been present in the cloud. There was apparently no odor of hydrogen sulphide and there is no evidence of the presence of other inflammable gases.

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* It is difficult to estimate the velocity of expansion of the eruption cloud at the time it reached the lake level. Generally accessible data show that a wind velocity of 100 miles (160 kilometers) per hour is sufficient to uproot large trees. Large trees were uprooted 2 kilometers inland from the west lakeshore. Since the velocity must have decreased very rapidly as the expansion progressed, it may have been as high as 200 miles (320 kilometers) per hour at the foot of the volcano. Wind moving with this velocity would exert a pressure of 200 pounds (Trautwine, John C., London, 17 ed. (1900), 321) per square foot (4 kilograms per square centimeter), sufficient actually to support a column of water 1 meter high. This estimate does not take into account the considerable inertia of the dense load of mud or ash which traveled with the wind, and which would increase its effect.

"The angular boulders thrown out ranged up to perhaps 300 kilograms in weight. The large rocks fell on the upper slopes of the volcano near the crater's rim. Andesitic specimens and others of basaltic character, neither with any appearance of recent fusion, were noted. . . . The blocks of tuff thrown out are identical in appearance with the bedded material of the crater walls. Some of the fragments weigh perhaps 200 kilograms. Other large pieces had broken from the impact of their fall. Bedding planes could be distinguished in many fragments. . .

"Fig. 1 shows the distribution of solid ejecta from Taal. Three roughly concentric areas have been outlined. The smallest one, 230 square kilometers, includes the devastated region where man and large animals were killed by the direct action of the volcano. It also limits approximately the area over which the fall of mud or ash exceeded 10 centimeters in average thickness. The next larger area is approximately that over which the average thickness of the fall of mud exceeded 1 centimeter. Over the largest area, 1,940 square kilometers, the mud formed a noticeable continuous coating, more than 1 millimeter (approximately) in thickness; beyond this limit it was only visible by close observation.†

"The greatest fall of material within the devastated area was on the west slope of the volcano. The maximum thickness of two meters noted here occurred where the ash and small fragments had drifted into an old water course. However, the ridges adjacent were all but bare, and therefore an estimate of 20 to 30 centimeters for the average maximum depth of fall for this vicinity is probably reasonable. . .

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* At Bañadero, where cool mud fell without violence to the depth of 1 centimeter, the leaves of the trees retained only a thin coating on their upper surfaces, yet within twelve hours many leaves and some fruit, such as oranges and wild fruits, had fallen, suggesting an effect of poisoning from the mud. Ultimately, all leaves and fruit in this section died. In several instances clothing, such as brown flannel shirts, white towels, etc., on which mud fell at Bañadero, was stained yellow. In San Pablo the fall of mud was very light, "like sugar sprinkled over a cake," yet garden plants were killed by it according to Mr. W. E. Crowe, supervising teacher.

† Comparing these areas to similar areas from the eruption of Mont Pelé in May, 1902 (see Hovey, E. O., *Am. Jour. Sci.* (1902), 14, 320), it develops that Taal devastated more than twice the area that Mont Pelé did, although the eruption was probably of much lesser magnitude. The ashes from Pelé spread over an area probably ten times as great as those from Taal. The crater of Mont Pelé is 1,280 meters above sea level, while Taal in places is as low as 100 meters. Thus the eruption from Mont Pelé had much more room for downward expansion, and the same energy at the crater threw its ejecta much higher in the air than in the case of Taal.

"The system of fissures which formed during this eruption is significant of the relation of Taal Volcano to the general structure of the region. This subject has been one of considerable interest to geologists who have studied this area. Centeno* placed Taal on an approximately north and south line with Mount Arayat in the central valley of Luzon north of Manila. Adams† thinks it probable that Mount Arayat is on the same structural line as Taal and argues that the general trend of structure in southwestern Luzon is to the northwest. However, he suggests the possibility of a line through Balayan Bay, Taal Volcano, and Laguna de Bay, and sees a possible elevated fault-block in the high ridge north of Lake Bombon and west of such a line.

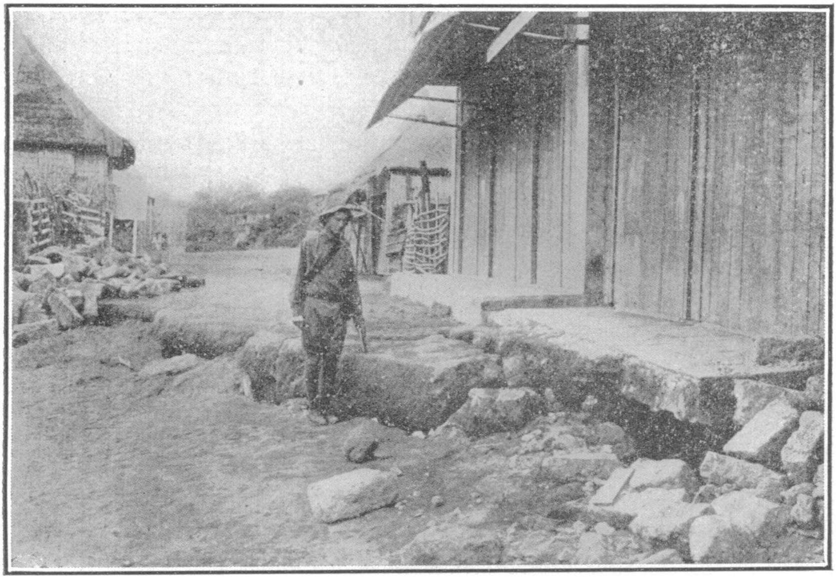

FIG. 3—Fissure in town of Lemery. Looking east.

"The trend of the recent fissuring indicates a line of weakness passing through Taal Volcano and bearing about N. 30° E. This trend extended beyond the limits of the system and runs closely parallel to the east coast of Luzon and the length of Palawan, passing through Laguna de Bay and Balayan Bay. The earthquakes were strongest in Taal and Talisay, along this line. The alignment of craters on Volcano Island conforms well with such a trend as do also the outline features of both island and lake. No recent fissure could be traced across the island itself, a fact scarcely explained by the greater fall of ash. If the fissures noted owe their trend entirely to movement radial from the crater their location is still significant, since careful search discovered no other radial fissures around the lake. The fissures are vertical, remarkably regular, and show only a vertical (no lateral) displacement. Where the displacement exceeds about 20 centimeters there is a sharp break and resulting scarp, otherwise only a gentle roll along the line of trend is evident. Generally speaking, the maximum displacement is along the central portion of the fissure, decreasing gradually to each end. It should be noted that displacement did not take place completely at the time the fissures appeared. It increased perceptibly for several days, during which earthquakes were frequent, after the opening of the fissures.

**Estudio Geológico del volcan Taal*, Madrid. Tello (1885).

† *Philippine Jour. of Sci.* Sec. A (1910), 5, 101.

"The two most prominent fissures occur along the bases of the walls of bedded tuff which form the main terraces of the Pancipit River Valley. Their vertical displacements vary up to about 3 meters, and their scarps face each other across the valley. The intermediate fissures have displacements not exceeding 1.5 meters (averaging about 0.8 meter). The whole system bears an evident relation to the existing structure. The intermediate fissures occur on relatively high ground, around which the Pancipit River makes a wide detour to the west. The ground surface slopes to the east, the strata (tuff) dip slightly to the east and the fissure scarps generally face the east. In the town of Lemery, a minor fissure leaves the general trend of the system to follow the contact between the tuff and recent alluvial for a short distance.

"There is a noticeable tendency to maintain the displacement along the trend of the system by alternate parallel fissures. One fissure begins where another ends; thus the system presents a staggered arrangement.*

"Along the main fissure in the town of Lemery the displacement was accomplished by dropping of the lower side, while the upper remained stationary. This is evidenced by the fact that the sea now comes inland farther than formerly on one side of the fissure, and remains at its old level on the other. Whether or not this was the usual occurrence is not certain, but judging from the positions of the two main fissures and the fact that the displacement generally took place after the earth stresses had apparently been relieved, this instance would be typical. . .

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* See Hobbs, William Herbert, Earthquakes, New York (1907), 72.

"Little violence, other than sharp earthquakes, seems to have accompanied the formation of these fissures. Natives say that a rush of gas occurred when the large one along the west side of the Pancipit Valley opened. Several people noticed clouds of dust shoot up along other fissures of the system. At Sinaysian, a *barrio* near the seacoast on the large fissure just mentioned, a number of gushing springs were noted soon after it opened. These springs are not exactly on the fissure, but occur irregularly over a small marshy area in the adjacent alluvial formation. On February 18, there were about twenty still very active, gas escaping into the air with considerable noise, and mud and water gushing up to a height of about one-half meter. . . Most of the springs had built up mud cones, perfect craterlets of fragmental tuff, perhaps 2 meters in diameter and 30 centimeters high. Both gas and water were at ordinary temperature. . .

"The most striking subsidence noted was that of Volcano Island itself. Here it was general around the whole perimeter, amounting to more than 3 meters in places. Longos Point was cut in two and the resulting small island is separated by water a meter in depth from the main island. . . A new beach is building over an old sugar-cane field on the southeast shore of the island. Cogon grass and stumps of trees with their roots intact could be seen all around the island beneath about 1 meter of water. The relative level of the lake is changed. It is lower by about 1 meter on its south shore line and is lower by a smaller amount on its north shore. The water in the upper part of the Pancipit River stands at a lower level now than formerly. The subsidence of Volcano Island would tend to lower the level of the lake on its shores but apparently not to such an extent as has occurred. It is not improbable that the whole shore line of the lake has risen slightly, reacting from the subsidence of the island at its center.

"Outwardly, Taal Volcano was little changed by the eruption. The absence of vegetation and the smooth drifted surface of the ash covering which is almost white in the sunlight, give the island an appearance of a vast snow heap. The crater rim is unbroken and save for minor fissures and cracks is intact. Sulphur is burning rather vigorously part way down its outside slope on the north side of the crater. This had never been noted before the eruption.

"The interior of the crater has been transformed. The well-known Green Lake and Yellow Lake, which were small bodies of water, one of which (Yellow Lake) was quite shallow, are gone. In the position of the former Green Lake there is a new one, the water of which appears milky-white, due to suspended solid matter. The level of this lake was on February 17 approximately 70 meters below that of the sea. Green Lake had stood 5 meters above sea level. Two streams of hot water, the combined flow of which was estimated at 100 to 150 cubic meters per minute, were pouring into the lake. These streams came out of the crater walls about 50 meters above the lake level, seeping from just over a layer of fine-grained, impervious, bedded tuff. On the west shore of the lake a conical rock 50 to 70 meters in diameter rose to a height of 115 meters above the lake level. The upper 50 meters of this natural obelisk appeared to be bedded tuff, but the lower portion is massive basalt. A week later, the streams pouring into the crater lake had increased both in volume and in number, and the lake itself had risen apparently about 5 meters. The present lake is boiling at a number of places and great volumes of steam arise from its surface. There is no evidence of a general subsidence in the crater. . . The new floor, exposed by the streams flowing across it, is composed of dense, basaltic material, hard and flowlike in appearance, certainly in place. It is probable that the change in the level of the crater floor was due to removal of material from the crater, not to the collapse or subsidence of the old floor.

"An approximation of the volume of solid material ejected from Taal Volcano is readily obtained by calculation from the data given in connection with the distribution of the ejecta. Disregarding irregularities in the ground surface, the volume of the solid represented by plotting sections, from the average depths shown, across the area covered, is 70 to 80 million cubic meters. Calculating in a similar manner the volume between the old and the new floor lines in the crater, according to areas and cross sections, the approximate figure of 45 million cubic meters is obtained for the volume removed above the level of the new lake. Examination of the crater walls below the old floor line reveals that a large portion of the material removed was rather dense, bedded tuff. If this material were ground up to a fine sand or ash and spread out in a thin layer, as mud, it would probably occupy at least one and one-half times its former volume, or about 68 million cubic meters. While these figures are approximate and represent at best only the order of magnitude of the volumes sought, yet it is evident that enough surface material was removed from the crater, allowing only a shallow depth for the new lake, to make up the volume of the solid ejecta. The appearance of the ejected mud, its low temperature, and its irregular character, all bear out the conclusion that it consists almost entirely of the material removed from the surface. The few incandescent stones may have come from slightly lower down in the volcanic throat, but even these were probably originally thrown out by former volcanic activity and were only worked over recently. . .

"The official report . . . estimates the human dead at 1,335. There were recovered and buried 732 bodies. Of these, 106 were found on Volcano Island and 618 along the west shore of Lake Bombon between the *barrios* of Subig and Bayungan, inclusive. Taal exerted a devastating violence over an area of approximately 230 square kilometers (part of this area was lake surface; the land surface devastated was about 98 square kilometers). The greatest distance from the volcano at which an appreciable depth of ash fell is about 52 kilometers. . .

RÉSUMÉ

"First, the eruption of Taal Volcano on January 30, 1911, was probably the most severe, considering the number of lives lost and the damage caused, the area of the region affected and the changes wrought in the volcano itself, which has occurred in historic times in the Philippines. It was of the explosive type, the violent activity continuing only a few hours, and the attendant phenomena being typical of this class of eruption.

"Second, the principal ejecta from Taal Volcano during this eruption were steam and volcanic ash or mud. Some incandescent stones were thrown out. The volcanic ash or mud probably resulted from the attrition, by mutual friction within the cloud, of bedded tuff which was torn from the floor of the crater. Little, if any, ejecta came (recently) from a great depth. The mud or ash spread over an area of 2,000 square kilometers.

"Third, the violent action of the eruption was more effective to the west of the volcano, due largely to the contour of the crater rim.

"Fourth, a system of earth fissures opened during the eruption, the trend of which indicates a tectonic line passing through Balayan Bay, Taal Volcano, along the probable fault block, the eastern scarp of which is marked by Mount Gonzales, and through Laguna de Bay. Towns along this line near the volcano suffered most from the earthquakes accompanying the eruption, and are most liable to damage from earthquakes during possible future eruptions.

"Fifth, general subsidence of the ground level took place over a considerable area after this eruption. The island on which the volcano is located subsided and the surrounding lake changed its level. The crater was materially deepened through the removal of material from its floor.

"Sixth, the most significant thing about this eruption is the probability that all its solid ejecta were surface material and the apparent absence even at the seat of volcanic activity of molten lava, which most theories of vulcanism require to account for this type of eruption.

"Seventh, the chief agent of destruction and the main cause of death resulting from the eruption was the explosive expansion of the escaping steam, which was violent owing to its movement and suffocating owing to its heat, its burden of mud, and a content of sulphur dioxide.

GEOGRAPHICAL RECORD

AMERICA

STATE GEOLOGICAL SURVEY OF ILLINOIS. Mr. Frank W. De Wolf, Acting Director, has obliged the Society with the following notes on the progress of the work of the Illinois Geological Survey during the past field season:

Mr. Fred H. Kay, formerly of the U. S. Geological Survey and the Southern Pacific R.R., was added to the force as Assistant State Geologist on July 1. He will especially work on a cooperative study of the mining industry, the other parties being the U. S. Bureau of Mines and the Mining Department of the University of Illinois.

Mr. R. S. Blatchley continued office work on a report on the Eastern Illinois Oil Field. This field produces in the neighborhood of 30,000,000 barrels annually. Mr. G. H. Cady and Prof. U. S. Grant of the Northwestern University were associated on a survey of quadrangles along the Illinois River in the vicinity of LaSalle. These include the section reaching from the Lower Magnesian limestone to the upper part of the Carboniferous and also two or more glacial drifts.

Prof. J. A. Udden of Augustana College, at Rock Island, made a geological survey of a quadrangle at that place. Similarly Prof. T. E. Savage finished work on the Canton Quadrangle in Fulton County.

Prof. Stuart Weller completed a very interesting survey along the Mississippi River, Monroe Co., where exposures occur from the Trenton up to and including the coal measures. The region is considerably folded and faulted and has been sufficiently eroded to offer excellent exposures. It is probably the most interesting region so far examined by members of the Survey.

Mr. E. W. Shaw of the U. S. Geological Survey continued co-operative work